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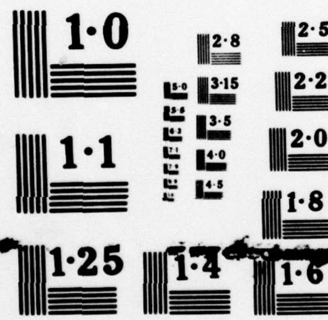

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PROJECT MANAGEMENT • DEVELOPMENT • MEASUREMENTS • INSTRUMENTATION • SYSTEMS • TRACKING • TARGETS • TEST • OPTICS - LASER • TELEMETRY • EVALUATION • ENGINEERING • ANALYSIS • COMMUNICATION • COMMAND-CONTROL • DISPLAY • SIMULATORS

LEVEL II

TEST AND EVALUATION SYSTEMS PROGRAM OFFICE

TECHNICAL MEMORANDUM NUMBER 106

COR DATA SYSTEM

27 March 1974

AIR FORCE SPECIAL WEAPONS CENTER

KIRTLAND AIR FORCE BASE NEW MEXICO

TECHNICAL MEMORANDUM NUMBER 106

COR DATA SYSTEM

[redacted]

27 March 1974

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(6) COR DATA SYSTEM. (9) Technical memo.,

1. General:

a. The COR area contains a collection of noncontiguous instrumentation sites which must be integrated in an autonomous range. In order for the COR to function as a unit, it is mandatory that instrumentation within COR be able to use metric trajectory (TSPI) data generated at any other location. In view of the large distances involved, and the mountainous terrain, continuous tracking may not be possible. The philosophy of central measurement and data reduction tend to inhibit real-time trajectory determination and sensor pointing. A distributed computing capability is required before the existing and planned facilities, including communications, can be effectively integrated into a real-time range required for operational testing. Where technically possible, every attempt will be made to remain data compatible with other ranges.

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b. An appropriate technical solution is feasible today only because of recent advances in small, high-speed computer technology, associated electronic production techniques and software standardization.

2. Technical Approach: The basic technical concepts necessary in the COR development are:

a. Data-on-time. Metric measurements must be "tagged" with that time associated with the measurement. This is in contract to the common "real-time operation," wherein all delays are assumed known or negligible. This assumption, never being absolutely true, introduces serious errors into the data. The concept that time is an invariant in this system is mandatory.

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b. <u>Universal Coordinate System</u>. Data must be readily available which will locate all participants in COR. It is necessary that a common data format be established early in COR development to inhibit the proliferation of many data structures and the use of diverse coordinate systems which will prevent the use of information at <u>any</u> and <u>all</u> locations that need it.

c. <u>Universal Calibration Reference</u>. The use of any but standard reference will also prevent the passing of useful data from one location to another. The data output or the use of data for control or scoring purposes must of necessity be related by a common reference. The use of the stars as the common reference is the only one known to be available at all locations.

3. <u>TSPI (Time, Space/Position, Identification)</u>:

a. Trajectory, not position, must be sent in the data stream for *TSPI purposes. Trajectory is defined as a data word which contains* position, velocity, acceleration as some appropriate epoch, i.e., TPVA. The epoch is normally not current time but some time in the past which correctly time tagged, position and its derivatives. These data may then be moved forward in time to the current epoch of use or observation.

b. The production of the trajectory data shall be accomplished at the sensor, i.e., radar, multilateration, etc., rather than sending a position data stream into a central processor. It is imperative that the trajectory produced by all metric systems on COR produce identical trajectories when tracking the same target.

4. <u>Calibration Capability</u>:

a. It is the intent of TESPO to use, as standard, a telescope which has as its calibration function:

(1) Accurate timing and time tagging (10^{-3} sec.),

(2) A geocentric data input,

(3) Evaluation of the instrumentation errors by direct observation against the stars (accurate pointing to approximately 40 stars randomly distributed in the hemisphere of observation to the least bit of encoders), and

(4) Connected so that errors due to dynamic lag are avoided.

The data from each trajectory system will be evaluated and adjusted against the standard telescope until a consistant and on-axis trajectory is obtained.

5. <u>Universal Geocentric Coordinate System</u>:

a. The coordinate system as referred to in 4a(2) known as "EFG" is the geocentric coordinate system used in the IRIG interrage vector. Position is determined by the projection onto each of three orthogonal planes. E is the plane of the prime meridian, F is the plane of the equator, and G is the plane of the axis of rotation of the earth.

b. A principle reason for selecting this coordinate system as the standard data system for COR is that one sensor can use data obtained from another location with only knowledge of an agreed on reference coordinate system in which the data are represented. The geocentric coordinate system, being independent of any one specific earth location, allows the

use of metric data independent of site locations of the data gatherer or the user. This capability is in contrast to the conventional use of topospherically formatted data, which is site dependent. A significant reduction in the amount of data which must be carried on the COR acquisition/ data buss is realized since we must transmit only the data itself, and not transmit the location or identification of the collection devices. One can readily see the significance of this when one considers that on COR large numbers of targets and instrumentation are required.

c. There are other good reasons for selecting a geocentric coordinate system such as:

(1) The dynamic update of the trajectory data to a new epoch may be done with standard numerical integration techniques, i.e., orbital generators. Many integration systems are readily available in both mathematical and software formats and require no development.

(2) The geocentric system is the natural coordinate environment when calibrating on the stars.

(3) The transformation from the sensor coordinate system (range, azimuth and elevation) is mandatory to some earth coordinate system before the data can be used at a remote location (topocentric or geocentric). The use of a geocentric one does not impose additional computational requirements on COR.

6. Data Resolution: A data register will be maintained within instrumentation to store the current trajectory on every target on COR. This trajectory will consist of a 240 bit word containing 36 bits of time, 90 bits of position, 48 bits of velocity and 21 bits of acceleration. The 36 bits

of time are 9 bits day of year (512 units) and 27 bits which is milliseconds in a 24 hour day. The 90 bits of position consists of 30 bits of E, 30 bits of F and 30 bits of G. The 48 bits of velocity are 16 bits of E dot, 16 bits of F dot, and 16 bits of G dot. In a like manner, seven bits of E double dot, F double dot and G double dot, comprise the acceleration part of the 240 bit word. Target identification will consist of a 9 bit word.

7. <u>Resolution Logic</u>: Thirty bits of position generally represent a number 11^{10} which is a number on the order of the number of feet to the moon. This then will give a resolution of one foot anywhere in a sphere 5×10^6 miles around the center of the earth. The 16 bits (6.6×10^4) give a resolution of approximately one foot/sec out to maximum orbital speed. The seven bits of acceleration (1.28×10^2) will cover maximum values of acceleration expected to be encountered. The maximum example of acceleration considered was based on the SPRINT and MINUTEMAN fourth stage. All values established above are beyond the values concerned in the aircraft and/or aircraft ordnance required. The values selected are those used at other Air Force installations and it is desirable that the COR remain compatible.

8. <u>Implementation</u>: All applicable instrumentation systems on COR will be physically connected to the data buss. The connection will include hardware register storage which contains 300 each 240 bit trajectory files. The internal use of each of these files will vary slightly at each

instrument. In general, however, for those systems which produce the trajectories, a correlation will be accomplished on a periodic basis to determine whether or not the individual trajectory requires an update. When the correlation evaluation indicates an update is required, then the new trajectory will be determined, and the new vector (trajectory) will be substituted on the data buss. This evaluation of the data buss should be done on a frequent basis, with a maximum interval being on the order of three seconds.

9. <u>Communication</u>: The 240 bit trajectory word describing the trajectory on each aircraft will be combined with other trajectory words to make up 2400, 4800, or 9600 bit per second data streams. 2400 bit per second system being used on most other ranges, but there is no technical reason why the higher data rate cannot be used on standard three kilohertz circuits. Since we are concerned with very large numbers of targets on occasion, it would appear economical to consider a programmable switching system which would allow reconfiguration of the range in terms of communication circuit routing and use. In general, it is anticipated that one would use one standard telephone circuit (3kc) for ten targets at 2400 bit/sec. When 300 targets are being controlled, this number may increase to 30 circuits, however, it is only in this special case where one need tie up that much communication bandwidth, and a reconfiguration would be in order for less demanding missions and operations.

10. __Instrumentation Data System__: Instrumentation such as radars when procured, do not normally contain data systems as such, but rather produce individual data outputs such as range, azimuth and elevation. The user generally must supply time as a local input. This data must be formatted into an acceptable format for transmission and/or on-site storage. Normally the data are reformatted to Mil 188B standards. The instrumentation is almost always in parallel data streams, especially if an internal data corrector (computer) is employed. Since most systems require a full duplex capability, i.e., data out, and acquisition data in and since all communication systems use serial data streams, a parallel to serial and serial to parallel converter is required, and must be installed directly between the instrument and the modem that connects to the data buss.

There are many individual suppliers of this capability, and there is available in Government channels, a hardwire low cost system currently being installed on the AFETR which should be considered for this use.

11. __Universal Independent Calibration Reference__: Stellar calibration provides the only independent reference available to all sensors located on or near the earth. The use of this universal reference is mandatory for such network operations as real-time trajectory data production and accurate hand-over operations.

a. The COR will contain many individual sensors or instrumentation. Normally metric devices are calibrated and/or evaluated against their own internal standards such as boresight targets or data massage on test targets. For use on COR, this will not be adequate.

b. It is imperative that a common reference be used to calibrate/ evaluate these many systems so that they all produce common metric data (TPVA) on a single target such as an aircraft.

c. The calibration of any system requires the evaluation/determination of the individual system error, both random and systematic. A particular caution is the determination of those errors whose value change in a low frequency period manner such as diurnal, seasonal or sun angle related periods. The best approach is the recursive and independent check of each term of the error model followed by an independent check against a standard such as the stellar fields, and this is the approach that will be used on COR. This is in contrast to the post test approach of regression modelling and coefficient determination, without the benefit of an evaluation against any standard.

12. Static Calibration: In this context, we shall define as calibrated any metric system which when using its internal error model can point to 20 to 40 stars randomly distributed in the hemisphere of observation to the least bit of the encoder. In order to do this, one must move a mount or instrument at sidereal rates and apply the total error model as corrections to the drive data. This is in contrast to the approach of tracking stars, or allowing the star to drift thru the field of view of the telescope. For those systems which do not point physical hardware, such as a phased array or multilateration system, then their data will be used to point an independent telescope in order to optically evaluate the errors within the system.

13. Dynamic Calibration: Upon the completion of the static evaluation and it has been determined that at least 20 randomly distributed stars are in fact pointed within the least bit of the encoder resolution, then the system is now ready for dynamic evaluation.

A dynamic target such as an aircraft, balloon, etc., will be used as the calibratic target vehicle. The instrumentation being evaluated will track the target and a record kept of the ability of the telescope to remain centered on the target to the least bit of the encoder system. The data produced by the system will be compared on a statistical basis to data produced by a fully calibrated ON-AXIS radar system if one is available.